JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1991, 56, 119-137 NUMBER 1 (JULY)

THE TRANSFER OF SPECIFIC AND GENERAL CONSEQUENTIAL FUNCTIONS THROUGH SIMPLE AND CONDITIONAL EQUIVALENCE RELATIONS

STEVEN C. HAYES, BARBARA S. KOHLENBERG, AND LINDA J. HAYES

UNIVERSITY OF NEVADA

The purpose of this study was to examine the transfer of consequential (reinforcement and punishment) functions through equivalence relations. In Experiment 1, 9 subjects acquired three three-member equivalence classes through matching-to-sample training using arbitrary visual forms. Comparison stimuli were then given conditioned reinforcement or punishment functions by pairing them with verbal feedback during a sorting task. For 8 of the 9 subjects, trained consequential functions transferred through their respective equivalence classes without additional training. In Experiment 2, transfer of function was initially tested before equivalence testing per se. Three of 4 subjects showed the transfer without a formal equivalence test. In Experiment 3, 3 subjects were given training that gave rise to six new three-member conditional equivalence classes. For 2 of the subjects, the same stimulus could have either a reinforcement or punishment function on the basis of contextual cues that defined its class membership. Experiment 4 assessed whether equivalence training had established general or specific consequential functions primarily by adding novel stimuli in the transfer test. Subjects treated even novel feedback stimuli in the transfer test as consequences, but the direction of consequential effects depended upon the transfer of specific consequential functions through equivalence relations.

Key words: stimulus equivalence, conditional stimulus equivalence, transfer of functions, specific versus general stimulus functions, verbal relations, matching to sample, humans

Stimulus equivalence is receiving increased attention by behavior analysts. Part of the interest may be because equivalence phenomena are not easily derived from traditional behavior-analytic formulations of stimulus control. Perhaps more importantly, however, the study of stimulus equivalence may constitute the beginning of a more adequate experimental analysis of verbal functions (Devany, Hayes, & Nelson, 1986; Hayes, 1986; Sidman & Tailby, 1982).

Equivalence relations would be of limited ultimate importance to psychologists (and of little use as a working model of verbal stimuli) if these relations did not combine with other psychological processes. Particularly important is the transfer of functions through equivalence relations (Hayes & Hayes, 1989). Two types of functions have been examined so far in the literature: discriminative functions and consequential functions.

Transfer of these kinds of functions is expected among verbal stimuli, although the process through which this occurs is unknown. For example, suppose a child is trained that the name for dogs is "dog." Later the child plays with a dog for the first time and enjoys it. Now, upon hearing the *words,* "there is a dog," the child may approach an area indicated by the speaker, even though a dog is not visible and the child may have no direct history of reinforcement for approaching upon hearing the word "dog." To the extent that equivalence provides a working model of verbal stimulation, we might say that dogs have become discriminative stimuli for approach directly through play, and the word "dog" has acquired a discriminative-like function, not through a direct history, but indirectly through its participation in an equivalence relation with dogs. The literature on the transfer of functions across equivalence relations supports the basic outlines of such an analysis. Transfer of discriminative functions has been shown across equivalence relations in simple equivalence classes (Hayes, Devany, Kohlenberg, Brownstein, & Shelby, 1987; Kohlenberg, Hayes, & Hayes, in press) and conditional equivalence classes (Wulfert & Hayes, 1988), and across symmetrically related stimuli (e.g., Catania, Horne, & Lowe, 1989; de Rose, McIlvane, Dube, Galpin, & Stoddard, 1988; Gatch &

Send correspondence and reprint requests to Steven C. Hayes, Department of Psychology, University of Nevada, Reno, Nevada 89557-0062.

Osborne, 1989; Lazar, 1977; Lazar & Kotlarchyk, 1986).

In much the same way, consequential functions seem to transfer through semantic relations. An English-speaking person learning for the first time that "good" in Spanish is "bueno" and that "bueno" in French is "bon" may respond to "bon" as a reinforcer without any direct history of pairing "bon" with primary reinforcers. "Bon" and "good" both function as reinforcers, but the histories involved may differ. "Good" may have acquired its conditioned reinforcement function directly, whereas "bon" acquired it indirectly through its participation in an equivalence relation with "good." There is much more limited support for this idea from the equivalence literature. Only one study has yet shown the transfer of reinforcement functions across equivalence relations (Hayes et al., 1987).

The purpose of the present study was to examine further the transfer of consequential functions through equivalence relations. The Hayes et al. (1987) study had two major methodological difficulties. First, only two comparison stimuli were used in training, a preparation with known difficulties (Sidman, 1987). Second, training was done through direct experimenter contact with the subject, allowing the possibility of accidental experimenter cuing. The present studies were designed to resolve these difficulties.

The present study also examined several additional issues. First, we attempted to distinguish general and specific consequential functions. Distinguishing between general and specific functions is an issue in all studies of transfer of functions. The structure of experimental tasks alone, given subjects' preexperimental histories, may establish particular general stimulus functions. For example, the presentation of stimuli following task performance in the manner usually associated with task feedback may establish these stimuli as consequences independently of any other contact with the specific stimuli involved. Transfer of functions through equivalence or other arbitrary relations may then go on to establish the specific stimulus functions (e.g., that Stimulus X is "good"). None of the transfer-of-function studies in the equivalence area has yet attempted to assess whether general or specific functions were transferring via equivalence relations. There are some indications, however, that the issue may be important. For instance, control subjects in the Hayes et al. (1987) study who were given novel stimuli as feedback stimuli tended to treat these stimuli as meaningful. This resulted not in random performances, but in either consistently "correct" or "incorrect" performances. Thus, general consequential functions may have been derived from the task structure itself in previous studies.

Second, the present series of experiments examined whether the transfer of functions depended upon the usual equivalence test. Some have argued that equivalence relations are likely to form when they are tested (Sidman, Kirk, & Willson-Morris, 1985). This is a difficult proposition to assess. If it can be shown that functions can transfer among stimuli before formal equivalence testing, this would at least suggest that an equivalence test, as it is usually performed in equivalence studies, is not necessary to the formation of these relations.

Third, the present study examined the transfer of functions through conditional equivalence classes. Semantic relations are always under contextual control. This may lead to contextual regulation of the functions of a given stimulus. For example, a teenager may learn to treat "that's bad" as a reinforcer when said by a peer but as a punisher when said by a parent. In the context of a peer, "that's bad" may be in an equivalence relation with "great"; in the context of a parent, "that's bad" may be in a relation with "terrible." This kind of situation was also examined in the present study. Finally, several controls were added that allowed the transfer of functions through equivalence relations to be distinguished from other processes.

EXPERIMENT 1

Method

Subjects and Setting

Nine students in introductory psychology participated in Experiment 1 for course credit. All subjects were scheduled for one 2-hr block of time and, when necessary to complete the experiment, were asked to participate in additional sessions. Subjects could decline to participate at any time.

Apparatus and Materials

Sessions were conducted in a room (3 m by 4 m), with subjects seated at a table on which were a color computer monitor and a keyboard. Stimulus equivalence materials consisted of arbitrary visual symbols, approximately 6 cm in diameter (see Figure 1 for those used in all four experiments). A sample appeared in the center of the top half of the monitor screen in a box (7 cm by 7 cm) made by a 0.25-cm red line, and three comparisons appeared at the bottom of the screen, each in a similar red box.

Stimuli used in the sorting task consisted of three-letter nonsense syllables, generated in sets of three syllables each. To ensure adequate differentiation, the first letter of each nonsense syllable within each set differed from every other first letter, but otherwise syllables were generated randomly (letter by letter) by the computer as needed. The syllable to be sorted appeared in the center of the top half of the monitor screen with three three-sided bins (7 cm wide) made by a 0.25-cm red line displayed at the bottom of the screen.

Procedure

All subjects were trained individually. The sessions lasted from 45 min to 2 hr. Instructions explaining task requirements appeared on the monitor.

Training consequential functions. The first three phases of Experiment 1 established one arbitrary visual stimulus as a conditioned reinforcer and another as a conditioned punisher via direct pairing with preexisting consequences. During each trial, one of a set of three three-letter nonsense syllables appeared at the top of the screen. Subjects sorted syllables into bins, selecting one of three red bins that appeared at the bottom of the screen. Sorting consisted of pressing one of three keys on the keyboard, corresponding to the left, middle, and right bin. After a key press, the syllable appeared in the bin selected, and a white line around the red bin blinked silently every 0.25 s. Pressing the enter key while the bin blinked confirmed the choice. To show that the choice had been confirmed, the white line around the bin blinked rapidly with short staccato notes played for 0.5 s. If the enter key was not hit, the bin stopped blinking after 2 s and a new choice could be made.

The instructions to the subject were delivered by the computer and were as follows:

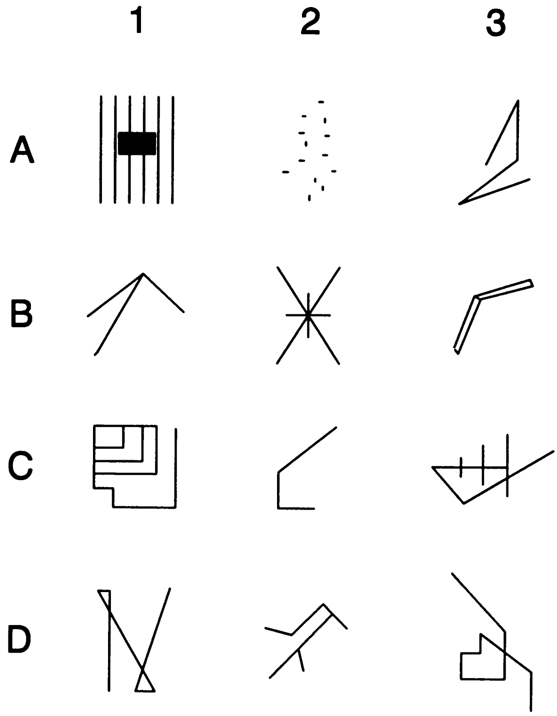

Fig. 1. The arbitrary symbols used in the conditional discrimination training and equivalence testing throughout all four experiments.

> In this part of the experiment your task is to sort syllables into bins. Do this by striking one of the three marked keys on the top row. While the bin is blinking white you may confirm your choice by hitting the enter key. You may change your choice by not hitting the enter key and when the bin stops blinking, making a new choice.

To ensure that the subject understood the instructions, a brief program then presented the subject with a syllable (not otherwise used in the experiment) and asked him or her to hit one of the bin selection keys and the enter key. When a subject did so, the program placed the syllable in the selected bin, blinked the bin rapidly with staccato notes, and displayed the words "Good. See how it works?" When the subject showed, by key pressing, that he or she understood the task instructions, the instructions concluded with: "During some parts of the experiment you may not receive any feedback. Remember, your task is to sort the syllables into bins."

Within each set of three nonsense syllables, one each was randomly assigned to be "correct" when sorted to the left, middle, or right bin. (Speaking of performances as "correct" and "incorrect" has generally been avoided by behavior analysts, but no other convenient semantic convention presents itself. We place these terms in quotes here to remind the reader that a behaving subject is always correct in a natural-science sense of the term.) Feedback initially consisted of three elements: a nonrepresentative visual form ("B1" or "B3"), a printed word, and a tone. If the sorting response was correct, the B1 stimulus immediately appeared in the upper right corner of the screen for 1 s, disappeared for 0.5 s, and then was redrawn. For incorrect responses, the B3 stimulus was used. After an additional second, and while the B1 or B3 stimulus remained on screen, the word "correct" or "incorrect" appeared for 2 s, superimposed on the particular B stimulus, which otherwise remained visible. While both remained on screen, a 2-s ascending (correct) or descending (incorrect) two-tone sound occurred. The next trial was then presented.

Sorting training was presented in 15-trial blocks; within each block each syllable was presented randomly five times. Training continued with the same three syllables until at least 90% of the trials were correct within a 15-trial block (i.e., no more than one error per 15-trial block). A criterion of 90% correct was used for all tasks throughout all experiments. A new set of three syllables was then created and sorted using the B1/B3 stimuli and the words "correct" and "incorrect" as feedback without the tone. If criterion was reached within 30 trials, a new set of three syllables was generated and sorted using the B1/B3 stimuli alone as feedback. If criterion was not reached in this test within 30 trials, training of consequential functions began again with new sorting stimulus sets and the original feedback stimuli (words, tones, and nonsense forms).

Conditional discrimination training. As soon as the B1 and B3 stimuli functioned as reinforcers or punishers in the sense that they could be used to train new performances, conditional discrimination training by way of a matching-to-sample procedure began. Each trial consisted of a sample appearing at the top of the screen for 2 s, followed by the presentation of three comparison stimuli at the bottom (e.g., A1 at the top and B1, B2, B3 at the bottom). A key press on one of the three designated keys resulted in a white box being drawn around the red comparison box selected, the white box blinking silently every 0.25 s. Pressing the "enter" key while the box blinked selected the stimulus. To show that the choice had been confirmed, the white line around the box blinked rapidly with short staccato notes played for 0.5 s. If the "enter" key was not struck, after 2 s the box stopped blinking and a new comparison could be selected. As soon as a comparison stimulus was selected, the word "correct" or "incorrect" appeared in the upper right corner of the screen, along with an ascending or descending two-tone sound, respectively.

The instructions to the subject were presented by the computer and were as follows:

> In this part of the experiment, your task is to note the symbol at the top and then to choose a symbol from the bottom. Do this by striking one of the three marked keys on the top row. While the box is blinking white you may confirm your choice by hitting the enter key. You may change your choice by not hitting the enter key and when the box stops blinking, making a new choice.

To ensure that the subject understood the instructions, a brief program then presented a sample and three comparisons (not otherwise used in the experiment) and asked the subject to press one of the marked keys corresponding to the three comparison stimuli and then the enter key. When a subject did so, the program blinked the box rapidly with staccato notes and displayed the words, "Good. See how it works?" When the subject showed, by key pressing, that he or she understood the task instructions, the instructions concluded with: "During some parts of the experiment you may not receive any feedback. Remember, your task is to note the symbol at the top and then to choose a symbol from the bottom."

Subjects were initially trained to select one of three comparison (B) stimuli in relation to one of three sample (A) stimuli (A1-B1; A2-B2; A3-B3). Each of the three stimulus pairs was first trained by itself (e.g., A1: B1, B2, B3 would be presented over and over with only the position of the comparisons varying), using 10-trial blocks. When a 90% criterion was reached on each, the three problems were mixed and presented in 18-trial blocks (in 18-trial blocks, the 90% criterion meant that no more than one error was permitted). Throughout the experiment, each relevant problem (e.g., A1-B1) was presented an equal number of times, in random order, in a given training or testing block. Training continued until the criterion (90% correct) was reached within a block of trials. Following A-B training, A-C relations were trained to criterion in the same fashion. A-B and A-C sets were then mixed and trained to criterion in blocks of 36 trials.

Equivalence testing. After the conditional discrimination training, subjects received a randomly ordered, 36-trial symmetry test on all B-A and C-A relations (B1-A1, B2-A2, B3-A3, C1-A1, C2-A2, C3-A3), with an equal number of presentations of each derived relation and no feedback. If criterion was not met, additional mixed A-B/A-C training was provided.

Upon meeting criterion in the symmetry test, the subjects then were presented with a similar 36-trial equivalence relation test on all six B-C/C-B relations (B1-C1, B2-C2, B3-C3, C1-B1, C2-B2, C3-B3), with no feedback. If criterion was not met, subjects received additional A-B/A-C training. Once criterion was met on all derived relations (C-A/B-A/B-C/C-B), subjects proceeded to transfer testing.

Transfer testing. Subjects were exposed to a sorting task identical to that used to train consequential functions except that new sorting stimuli were generated and only C1 and C3 stimuli were used as feedback. Subjects were exposed to the sorting task in 15-trial blocks. Reaching a 90% correct criterion in a block terminated the experiment. If after six 15-trial blocks criterion was not reached, a new set of sorting stimuli was generated and the B1 and B3 stimuli were retested for consequential functions in a 15-trial block. Failure in this task lead to a retraining of consequential functions. Whether or not the B stimuli had retained their effects, subjects were then also retrained in the underlying conditional discriminations and readministered symmetry and equivalence tests. The transfer test was then repeated with a new set of sorting stimuli. The second test was limited to a maximum of three blocks of 15 trials.

Results and Discussion

The number of training trials and testing results for all 9 subjects are seen in Figures 2 and 3. Eight of the 9 subjects showed a transfer of consequential functions through a three-member equivalence class. All subjects learned via direct training to treat B1 and B3 as indicators of correct and incorrect responding. Eight of the 9 subjects required 75 to 120 trials; 1 subject took 315 trials. All subjects also acquired the conditional discriminations. A-B and A-C relations were learned in 48 to 76 trials each. All subjects then immediately reached criterion in the first 36-trial block of mixed A-B/A-C training.

Six of the 9 subjects (1, 2, 4, 5, 6, 7) immediately reached criterion on a symmetry test. The remaining 3 subjects (3, 8, 9) passed after a single reexposure to A-B/A-C mixed training. All subjects passed the equivalence test as soon as symmetry was acquired.

The transfer test was the main focus of Experiment 1. Successful completion of this test required that the subjects treat C1 as correct and C3 as incorrect. The only relation between the B stimuli (with directly trained consequential functions) and the C stimuli was their common relation to the A stimuli. Six of the 9 subjects (1 through 6) showed the transfer on their first sorting problem (see Figure 2). Three subjects (2, 3, 4) did so in the first 15-trial block; 2 subjects (1, 6) took two blocks, and 1 subject (5) took four blocks. The data for the 2 subjects (2, 4) who showed perfect performance in the first block of trials are not as surprising as they appear because subjects who respond correctly to the functions of the C stimuli can eliminate alternatives once even a single lucky guess is made about the correct position for a given syllable. If the first guess is correct (which it should be one out of three times), the next type of syllable must go into one of only two remaining sorting bins. Multiplying the two probabilities and assuming functions for the consequential stimuli, perfect performances should be expected one out of six times.

The remaining 3 subjects (7 through 9) got virtually none of the problems correct in the initial six blocks of 15 trials (see Figure 3). Subject 8 showed on retesting that the B stimuli were no longer functioning to criterion as reinforcers and punishers. After retraining and equivalence testing, this subject passed the transfer test, requiring three 15-trial blocks. For Subject 7, the B stimuli had retained their consequential functions and, after a review of

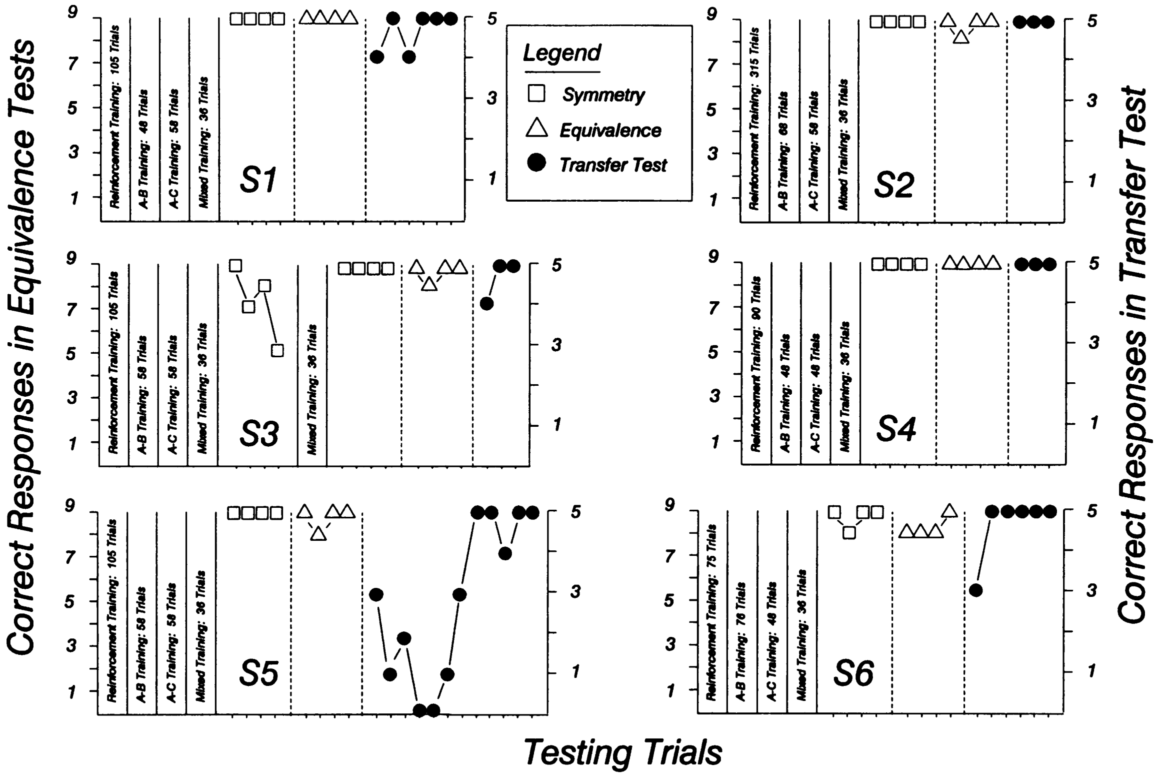

Fig. 2. The performance of Subjects 1 through 6 during training and symmetry, equivalence, and transfer tests in Experiment 1. Each data point represents nine trials for the symmetry and equivalence tests and five trials for the transfer tests.

training, this subject passed the next sorting transfer test in two blocks of trials. Subject 9 also still showed the consequential functions of the B stimuli but failed to show successful transfer of these functions to the C stimuli in the second transfer test.

Experiment 1 showed, with a single exception, that consequential functions established with one member of an equivalence class seemed to transfer to another member of that class. Six of the 9 subjects showed the effect in the first testing period, and 2 additional subjects demonstrated it in the second testing period.

In Experiment 1, the B stimuli were given a consequential function before they were seen in a matching-to-sample format. This might facilitate the transfer of functions throughout an equivalence relation because the functions of the stimuli could participate in the conditional discrimination training itself. In Experiment 2, the sequence of consequential training and matching-to-sample training was reversed so that conditional discriminations involved only novel figures. Experiment 2 also addressed a direct pairing interpretation of the results of Experiment 1. The B and C stimuli had been seen together in the equivalence test, and a successful equivalence test involved the direct temporal pairing of B and C, as the subject first looked at one and then selected the other. Thus, although the equivalence test performance per se may reflect equivalence relations, the direct pairing of stimuli produced by the test performance might explain the transfer of functions observed. In Experiment 2, we addressed this issue in two ways. First, we assessed for a transfer of functions before any equivalence testing. Second, if such testing was necessary, only symmetry tests were used. This ensured that the stimulus with trained consequential functions never ap-

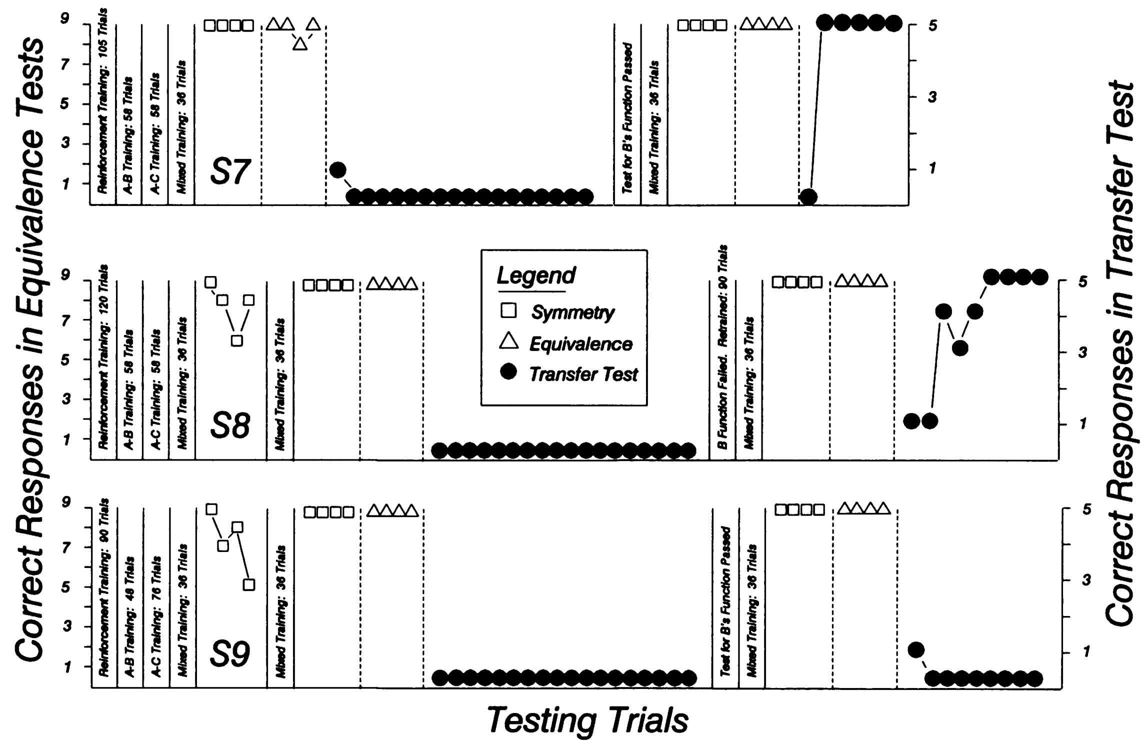

Fig. 3. The performance of Subjects 7 through 9 during training and symmetry, equivalence, and transfer tests in Experiment 1. Each data point represents nine trials for the symmetry and equivalence tests and five trials for the transfer tests.

peared together with stimuli used as consequences in the transfer test. Finally, larger classes were used in Experiment 2.

EXPERIMENT 2

METHOD

Subjects and Procedure

Four subjects (2 males and 2 females), similar to those in Experiment 1, served in Experiment 2.

Training and testing procedures were basically as described in Experiment 1. There were modifications in the sequencing of phases to permit training and testing of consequential effects after the underlying conditional discriminations were trained, and to establish larger classes. Other minor changes were made. Specifically:

1. Within each set (A-B, A-C, and A-D), problems were randomly mixed in 15-trial blocks (five trials for each relation), without first having 10-trial blocks of single component problems. For example, during A-B training, A1-B1, A2-B2, and A3-B3 relations were trained in a randomly mixed block without first separately training each relation as in Experiment 1. After A-B, A-C, and A-D training, all problems were randomly mixed in a 27-trial block, with three presentations of each trained relation.

2. Symmetry testing (B-A, C-A, and D-A in a randomly mixed 18-trial block covering each of the nine derived relations twice) was conducted as in Experiment 1, but only if subjects first twice failed the transfer test. No additional equivalence tests were used.

3. Conditioned reinforcement and punishment training were conducted as before. However, this phase appeared after the conditional discriminations had been mastered. Two transfer tests involving different sets of nonsense syllables then followed immediately, one with C1/C3 as in Experiment 1 and the other with a random mix of C1 and D1 for correct answers and C3 and D3 for incorrect answers.

Results and Discussion

The results for all 4 subjects can be seen in Figure 4. All subjects apparently showed transfer of consequential effects through the three-member equivalence classes. Subjects required between 102 and 117 conditional discrimination training trials before reaching criterion (90%). Subjects required between 60 and 165 training trials before the B stimuli functioned predictably as consequences. Three of the 4 subjects (21, 22, and 23) showed transfer of consequential functions to the C stimuli on the first transfer test. These 3 subjects also showed transfer to the mixed C and D stimuli; each took three blocks of trials to reach criterion (see Figure 4). Note that these transfer tests occurred in the absence of any equivalence testing of the usual type. The C and D stimuli acquired the functions of the B stimuli for these subjects even though the B, C, and D stimuli had never appeared together in any way.

Subject 24 initially responded consistently incorrectly in the transfer test. After receiving additional conditional discrimination training, he responded in the same fashion. The consistency of his responding suggests that the experimental task itself had defined these stimuli as consequential because the subject was apparently treating the C1 stimulus to mean "incorrect" and the C3 stimulus to mean "correct." This pattern had also been seen in Experiment 1 (Subjects 7 and 8) in the early phases of testing. It is possible that Subject 24 was doing so because equivalence relations had not formed. This kind of performance has been seen in other transfer of function studies when equivalence testing was delayed until after transfer had been assessed (Wulfert & Hayes, 1988). However, after equivalence relations were tested, transfer then occurred (Wulfert & Hayes, 1988). Thus, Subject 24 was exposed to symmetry testing after additional mixed conditional discrimination training. He reached criterion on this symmetry test. On the next transfer test (following additional reinforcement training), his performance met criterion on the C stimuli but then failed to do so on the mixed C and D stimuli. He was given additional conditional discrimination and reinforcement training, after which he displayed a performance just short of criterion on the first C transfer test. He then received additional conditional discrimination and reinforcement training, and met criterion both with the C stimuli and with the C and D stimuli.

Experiment 2 provides evidence that consequential functions can transfer through equivalence relations without training of these functions before conditional discrimination training. Three of the 4 subjects showed the effect without any formal equivalence testing, and the 4th subject demonstrated the effect after symmetry testing. In addition, no subjects ever saw the B, C, and D stimuli together on the screen during the experiment. Thus, direct pairing is unlikely as an explanation for the results. All subjects showed the effect with four different stimuli simultaneously (C1, D1, C3, and D3). It is possible, however, that the initial test with the C stimuli only made participation of the D stimuli in the equivalence class unnecessary for transfer to occur. Once subjects learned that C1 meant "correct," they could determine that any stimulus shown as a consequence for the same sorting performance must also mean "correct." Future research on the size of classes and the transfer of functions should test the various stimuli separately for transfer effects to avoid this problem.

In Experiment 3 we attempted to extend the findings of Experiments 1 and 2 to conditional equivalence relations. The stimuli changed class membership such that a given stimulus was sometimes in a class with a correct stimulus and sometimes in a class with an incorrect stimulus.

EXPERIMENT 3

Method

Subjects

The 8 subjects who showed transfer of consequential functions through simple equivalence classes in Experiment 1 were invited to be subjects. Five of the subjects did not have time for the additional experimentation. The remaining 3 subjects served in Experiment 3.

Procedure

The sequence and nature of training and testing were identical to that used in Experiment 1, except that another set of nonrepresentative visual stimuli was used in the matching-to-sample training, and subjects received second-order conditional discrimination training, conditional equivalence testing, and a con-

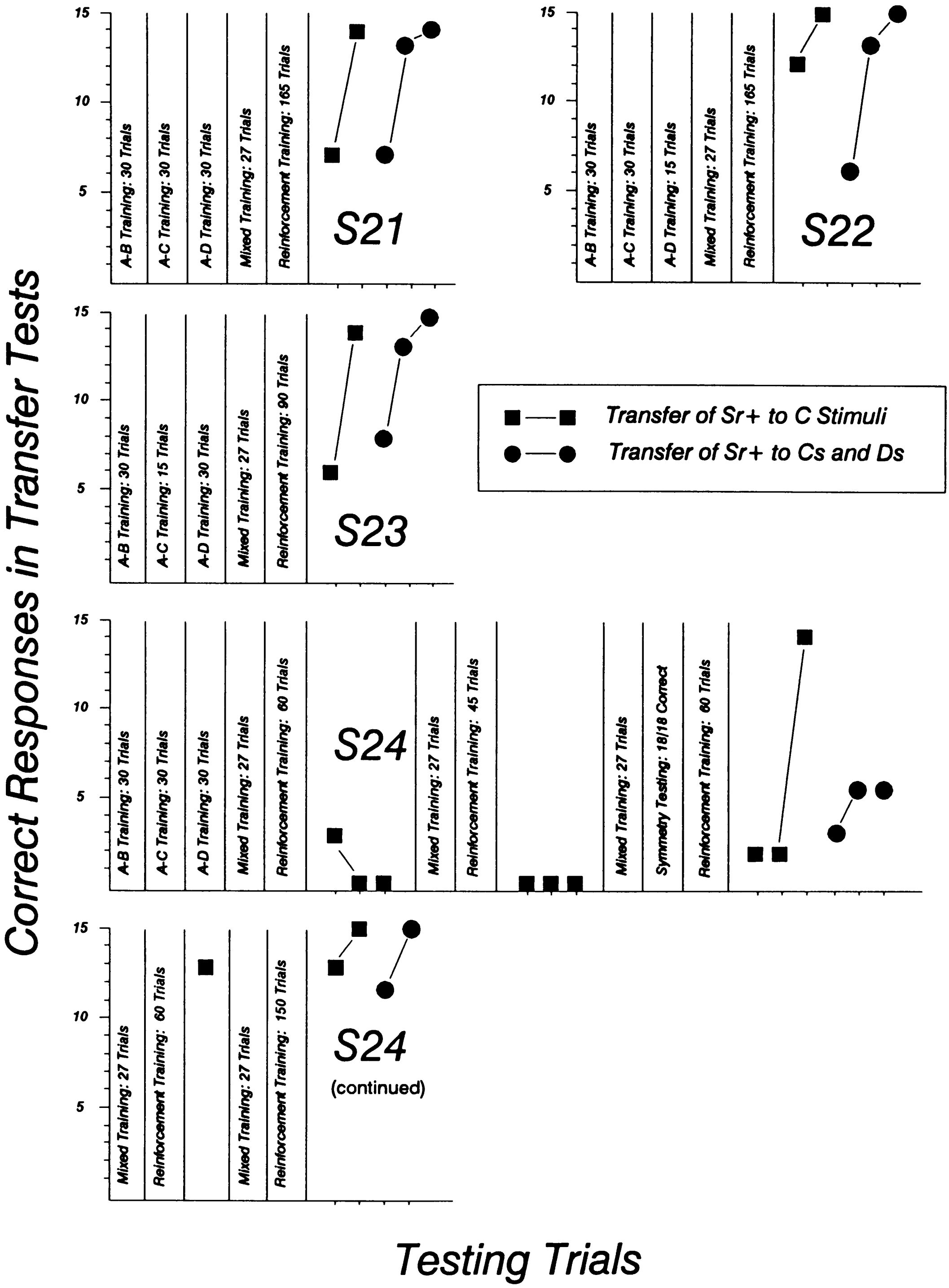

Fig. 4. The performance of Subjects 21 through 24 during training and symmetry and transfer tests (to C stimuli and C and D stimuli) in Experiment 2. Each data point represents 15 trials on the transfer tests.

ditional transfer of function test as described below. The contextual stimulus used for the second-order conditional discrimination testing was a 2-cm wide red or green border around the screen periphery, inside of which the conditional discrimination training occurred. When the border was red, subjects received the conditional discrimination training necessary to form three three-member equivalence classes: A1, B1, C1; A2, B2, C2; A3, B3, C3. When the border was green, the classes trained were A1, B1, C3; A2, B2, C2; and A3, B3, C1. Thus, the C1 and C3 stimuli changed class membership under the two contextual cues.

The initial training of consequential functions (the first phase of this experiment) was conducted with neither a red nor green contextual cue and was identical to the training in Experiment 1. Six A-B relations were trained (Red: A1-B1, A2-B2, A3-B3; Green: A1-B1, A2-B2, A3-B3). As in Experiment 1, subjects were first trained on each specific relation separately in 10-trial blocks before being exposed to 18-trial blocks of these six relations randomly mixed (three trials per relation). During the mixed A-B training blocks, the border was randomly red or green half of the time, but the correct comparison remained the same in either contextual condition. The A-C relations were then similarly trained but in this phase the same stimulus could be correct or incorrect as related to the same sample, depending upon the contextual cue (Red: A1-C1, A2-C2, A3-C3; Green: A1-C3, A2-C2, A3-C1). When criterion was met, subjects were then presented with 36-trial blocks of randomly mixed A-B/A-C training (three trials each of all 12 trained relations). When the criterion was met, the subjects then received a randomly mixed 36-trial symmetry test on all B-A and C-A relations under both contextual conditions (three trials of each of 12 relations). If criterion was not met, mixed A-B/A-C trained recommenced. If the symmetry criterion was met, subjects were exposed to a 36-trial randomly mixed test of all B-C and C-B relations in both contextual conditions (three trials of each of 12 relations). If the equivalence criterion was not met after a 36-trial block, A-B/A-C training recommenced. If criterion was met, a transfer test was presented without further tests for equivalence.

The transfer test was identical to that in Experiment 1 (to which these subjects had been exposed) except that new sorting stimuli were used for each test and the two contextual cues now appeared around the periphery of the sorting task screen for the first time. Three syllables were sorted as before, but now when the border was red, C1 followed correct sorts and C3 incorrect sorts; when the border was green, C3 followed correct and C1 incorrect sorts. The contextual cue was varied randomly across sorting trials during 15-trial blocks.

Results and Discussion

The results for each subject are shown in Figure 5. Two of the 3 subjects showed the transfer of function during the first transfer test. The 3rd subject showed above-chance performance but dropped out of the experiment before retraining could occur. Subjects required 230 to 312 trials to acquire the conditional discriminations. Each required 90 trials to establish the B stimuli as effective consequences. All 3 subjects met criterion on the conditional equivalence tests (see Figure 5). Subjects 3 and 5 also reached criterion on the transfer of function test, requiring four and two 15-trial blocks, respectively.

Subject 8 met criterion on both the symmetry and the equivalence tests. However, after six blocks of transfer test trials, this subject's scores ranged from 73% to 40% correct. Overall, he sorted 51 of 90 correctly while chance would yield 33% correct (30 of 90), a statistically significant difference when assessed using a binomial test ($z = 2.01$, $p < .05$). Before retraining and a second test, the subject left the experiment because of time constraints.

The results of Experiment 3 provide evidence for the transfer of consequential functions through conditional equivalence classes. To pass the transfer test, the subjects had to treat both C1 and C3 as correct in one context and incorrect in another. Subject 8 did not show the effect clearly. This subject also failed to show transfer of consequential functions in Experiment 1 until having had extensive training. Extensive retraining with the more complex situation offered in Experiment 3 could not occur because the subject discontinued participation.

There are still several interpretive ambiguities with the results from Experiments 1, 2, and 3.

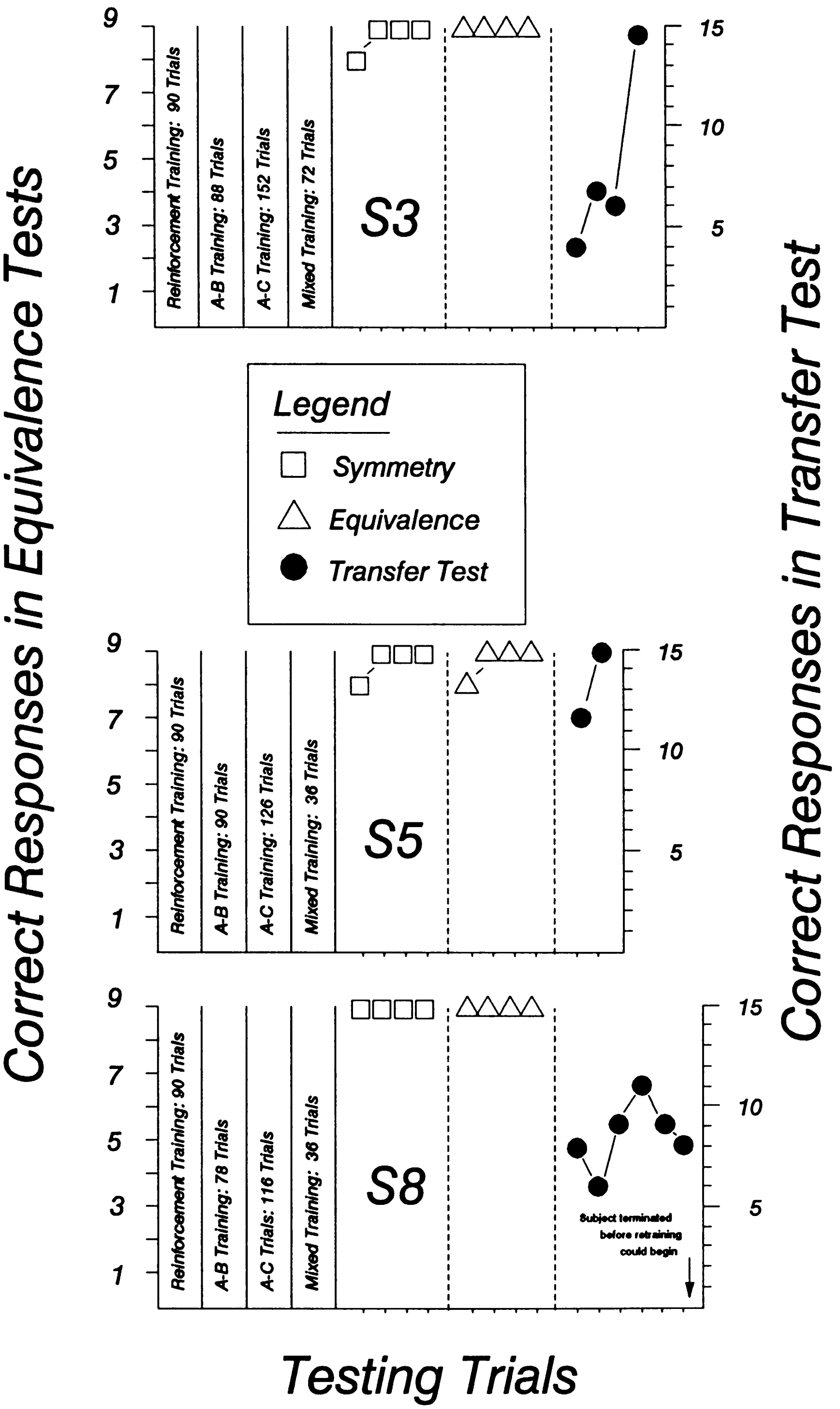

Fig. 5. The performance of Subjects 3, 5, and 8 during training and symmetry, equivalence, and transfer tests in Experiment 3. Each data point represents nine trials for the symmetry and equivalence tests and 15 trials for the transfer tests.

1. Subjects may respond to one of the feedback stimuli as though it means "correct" and the other as though it means "incorrect" even without conditional discrimination training. When subjects failed a transfer test, they tended to do so by responding consistently incorrectly (e.g., see Subjects 7, 8, and 9 in Figure 3 or Subject 24 in Figure 4), as if they had assigned reverse meanings to the consequential stimuli than those expected. This effect has been seen in several previous transfer of function studies (e.g., Hayes et al., 1987). In the present experiments, all subjects had a history with the sorting task prior to transfer testing. Thus, direct experimental histories and similar extra experimental histories may have established that stimuli presented in the upper right corner of the screen following sorting trials were consequences of some kind and thus must have meant either "correct' or "incorrect." Without derived equivalence relations between the B and C stimuli, the specific valence of these consequences may be determined by idiosyncratic histories (e.g., one C stimulus may "look good" to the subject). When equivalence relations between the B and C stimuli are derived, specific consequential functions may be due to the transfer of functions via equivalence relations. This distinction between general consequential functions and specific consequential functions was examined in Experiment 4.

2. Especially if general consequential functions are established by the structure of the task itself, repeated training or testing or extensive exposure to testing problems may provide feedback regarding the assigned functions of the C stimuli. If one were to put this process into words, it would be something like, "This apparently is not working because I am seeing the same problem over and over. One of these figures must mean correct. Maybe I've assigned them incorrectly. Let's try reversing the assignment." An attempt was made to minimize this factor by limiting recycling and the length of the transfer test. Nevertheless, meeting criterion in the transfer test terminated the experiments—recycling was contingent. To control for possible effects due to contingent training or testing, in Experiment 4 sorting tasks occurred one at a time for a set length, and both the number of sorting tasks and the number of testing phases were the same for all subjects. In addition, each sorting problem was presented only a small number of times, regardless of performance.

3. In the previous experiments, the sorting task had three sorting choices. Subjects might conclude that the feedback stimulus shown only after one placement in a given problem meant "correct," whereas the feedback stimulus shown after either of the other two placement options meant "incorrect." Up to 30 exposures to a given sorting stimulus were possible within a transfer test, which could provide sufficient opportunity to notice the relation. In Experiment 4, a two-choice sorting task was used to eliminate this possibility.

4. There was little control for stimulus preferences in Experiments 1 and 2; C1 and C3 might have functioned as a reinforcer and punisher, respectively, because of their physical appearance. Each C stimulus was used as a reinforcer or punisher for an equal number of subjects in Experiment 4.

EXPERIMENT 4

METHOD

Subjects and Procedure

Forty-four naive subjects, similar to those in the other experiments, served in Experiment 4.

The procedure (including instructions) was identical to that in Experiment 1 with the following exceptions:

1. The transfer task consisted of 20 problems that were presented sequentially. Subjects were shown a randomly generated nonsense syllable five times in a row. Only two bins were provided for sorting. After five sorts, regardless of performance, a new syllable was generated for sorting. This procedure eliminated the contingency between performance in the test and the length of testing.

2. The same sorting procedure (described above) was used to train the original consequential functions for the B1 and B3 stimuli. Each of the 20 syllables was sorted five times each. If the last four sorts of a given syllable were correct, the problem was considered to be solved. The criterion for each part of the training of consequential functions (the part using the tone, verbal feedback, and B stimuli; the part using the verbal feedback and B stimuli; and the part using the B stimuli) was that the last 10 problems in a block were solved correctly. If criterion was not reached in train-

ing using the tone, verbal feedback, and B stimuli or training using the verbal feedback and B stimuli, additional sorting problems were added until 10 problems in a row were solved. If criterion was not reached in training using only the B stimuli, training using the tone, verbal feedback, and B stimuli recommenced.

3. To avoid any contingency between performance and the number of testing phases, a blind recycling procedure was used. After subjects had learned the consequential functions, had learned the conditional discriminations in the matching-to-sample task, and had been exposed to the transfer test, they were then retrained to criterion on the original consequential functions and conditional discriminations regardless of their performance in the transfer test. A final transfer test concluded the experiment.

4. Half of the subjects were in a control condition. These subjects received different stimuli in the matching-to-sample task from the original C1 and C3 stimuli, but, like the experimental subjects, were shown the original C1 and C3 stimuli (which the control subjects had never seen before) as feedback stimuli in the transfer task.

5. To control for possible stimulus preferences, half of the subjects in both the experimental and control conditions had C1 assigned to be correct and C3 assigned to be incorrect; half had reversed assignments. For the experimental subjects, this reversal was accomplished by training that (using the original stimulus names) formed the classes A1, B1, C3; A2, B2, C2; A3, B3, C1, rather than A1, B1, C1; A2, B2, C2; A3, B3, C3. Because the control subjects did not see the original C1 and C3 stimuli until the transfer test, the "reversed assignment" for them was simply a matter of how their performances in the transfer task were evaluated by the experimenter.

Table 1

Number of sorting tasks reaching criterion (out of 20) in Experiment 4.

Experimental condition			Control condition		
Subject	Test 1	Test 2	Subject	Test 1	Test 2
C1, correct; C3, incorrect					
1	20	20	12	18	20
2	20	20	13	18	20
3	20	20	14	8	7
4	20	20	15	19	20
5	20	20	16	20	20
6	20	20	17	0	20
7	19	20	18	20	20
8	18	—[a]	19	20	20
9	20	20	20	4	5
10	20	20	21	18	20
11	16	20	22	9	6
M	19.4	20.0		14.0	16.2
C1, incorrect; C3, correct					
23	14	—[a]	34	20	20
24	20	20	35	7	17
25	20	20	36	0	0
26	20	20	37	3	1
27	20	20	38	20	15
28	20	20	39	4	11
29	20	20	40	17	16
30	14	20	41	20	20
31	20	20	42	0	0
32	8	20	43	0	0
33	20	20	44	19	20
M	17.8	20.0		10.0	10.9
Grand *M*	18.6	20.0		12.0	13.6

[a] Subjects left experiment before finishing. Subject 23 could not complete the retraining and then discontinued participation.

Results and Discussion

Experimental subjects solved an average of 18.6 of 20 sorting problems in Test 1 and 20 of 20 in Test 2 (see Table 1). A solved problem was defined as one that was sorted correctly on the last four trials of a given five-trial sorting problem. The control subjects solved an average of 12 of 20 problems in the first transfer test and 13.6 in the second test. Eighteen of 22 subjects reached criterion in the first transfer test (using the usual 90% correct criterion, or 18 of 20 problems solved), and 20 of 20 subjects (2 subjects dropped out) did so in Test 2. In contrast, 11 of 20 control subjects reached criterion in both Tests 1 and 2. The difference between the number of subjects in the experimental and control groups reaching criterion was statistically significant ($p < .05$) for both Tests 1 and 2 (Test 1: $df = 1$, $\chi^2 = 4.95$; Test 2: $df = 1$, $\chi^2 = 13.55$). The difference between the number of problems solved by subjects in the two groups was also statistically significant when examined with a Mann-Whitney U test (Test 1: $z = 3.00$; Test 2: $z = 2.09$). These two analyses were not corrected for ties, which yields a more conservative test.

Most subjects tended to act as if one of the feedback stimuli meant "correct" and one meant "incorrect." If possible scores are divided into thirds, only 6 of 86 test scores fell into the middle range of 7 through 13. One was in the experimental group (Subject 32, Test 1), and five in the control group (Subject 14, Tests 1 and 2; Subject 22, Test 1; Subject 35, Test 1; and Subject 39, Test 2). Many control subjects solved all the problems correctly; others solved no problems. In both cases, however, the consequences were being responded to consistently (i.e., the zero scores were not due to random sorting patterns but to reverse assignment of consequential functions). For most (but not all) subjects, the C stimuli had general consequential functions even without the involvement of equivalence relations. The specific direction of consequential functions was not determined by the physical form of the C stimuli but by idiosyncratic preferences by the control subjects and by derived equivalence relations for the experimental subjects.

There is little indication that subjects took the recycling to indicate incorrectness and thus changed their performance, or that they changed their performance for other reasons. Again dividing scores into thirds, only 1 subject (17) had a score in an extreme third in Test 1 followed by a score in the other extreme third in Test 2. This makes more plausible the view that changes of assignment seen in earlier experiments (Subjects 7, 8, and 24) were due to interposed equivalence training or testing.

Finally, Experiment 4 controlled for the possibility that different frequencies of feedback stimuli could have explained the sorting results from Experiments 1, 2, and 3. The sorting task used in Experiment 4 had only two choices. As such, subjects could not have derived which feedback stimulus meant "correct" or "incorrect" by the number of positional assignments producing the stimulus.

GENERAL DISCUSSION

The present experiments were designed to determine whether consequential functions given to a member of an equivalence class will transfer to other members of the class without explicit training. The data suggest that they will. This transfer seems to occur whether the function is established before or after the underlying conditional discriminations are trained and, for most subjects, does not depend on the presence of the usual equivalence test for its occurrence. Consequential functions also transfer through conditional equivalence classes, such that the functions of a given stimulus can be reversed in each of two contextual conditions in accordance with the relations derived in those conditions.

The consequential functions that have been shown to transfer, however, are specific, not general. It was found in Experiment 4 that even novel feedback stimuli can have reinforcing or punishing functions. Nevertheless, when given the opportunity to assign specific consequential functions on the basis of equivalence, all but 1 of the 35 subjects in Experiment 4 apparently did so after sufficient exposure to the task. This consistency across subjects does not seem to be due to incidental pairing of stimuli, contingent training or testing, or physical properties of the stimuli themselves. It is the relative consistency of the effect, especially when contrasted to the performance of the control subjects, that provides the strongest evidence for the derivation of specific consequential functions via the transfer of functions through equivalence relations.

The transfer of stimulus functions is not immediate or automatic. Several subjects (e.g., Subjects 7 and 8 in Experiment 1, Subject 24 in Experiment 2) showed the transfer only over time, and one did not show it at all (Subject 9 in Experiment 1). An important point is that it seems logically necessary that the transfer of functions through equivalence classes be under contextual control (Hayes, 1991; Hayes & Hayes, 1989). Any stimulus event has many functions, at least of a perceptual sort. If all the stimulus functions of a stimulus transferred completely to another stimulus and vice versa, there could be no psychological basis upon which to distinguish them. Thus, how are subjects to know that it is the consequential functions of "correct" that are to transfer, and not, say, the visual functions or auditory functions? In the present case, the sorting context, the placement of the consequential stimuli, and so on, may have selected the specific consequential functions of the B stimuli as relevant to the C stimuli and not other functions of the B stimuli, such as their shape, odor, or texture. In another context, other functions could be selected.

Pursuing answers to questions about transfer will be difficult and will raise issues that are already pervasive in human operant research. Human subjects have extensive preexperimental histories, particularly verbal ones, and are actively verbally construing experimental preparations. Minor details of procedure can provide the basis for responding. Consider, for example, the cues that might permit novel stimuli following a response to function as feedback. Extensive preexperimental histories (putting aside for the moment the experimental instructions themselves) may lead the subject to identify aspects of a task as a "problem to be solved." Some kind of feedback—whether arbitrary or intrinsic to the task itself—would be expected in such a situation. There is no other way to detect achievement of a "solution." Response-produced stimuli could be taken to mean either "correct" or "incorrect" on this basis alone. In addition, the present preparation provided experimental histories of this kind. For all subjects, the consequential effects of the B stimuli were trained in the sorting task by presenting verbal feedback and tones and placing the B stimuli in the upper right hand corner of the screen. When novel stimuli (for control subjects in Experiment 4) later appeared, their position on the screen and their relation to task completion (having just pressed the enter key) may have defined these cues as "feedback" on the basis of stimulus generalization. In addition, similar tones were used as feedback in both the conditional discrimination training and as part of the sequence used to establish the B stimuli as consequences. Because the tones were clearly feedback and the B stimuli were clearly feedback, by extension, the novel stimuli must be feedback.

The presence of general effects of this kind can be inferred in already published studies. All of the control subjects in Hayes et al. (1987), for example, showed either 0% or 100% correct performances on the transfer of either discriminative or reinforcement functions. Several strategies might be useful to detect, manipulate, or control for the variables involved in transfer-of-function studies. These include the strategies discussed next.

Use of Novel or Nonequivalent Stimuli

Whenever transfer apparently due to equivalence is assessed, it is important to assess the effects of the same stimuli when they are novel or known but not members of the equivalence relations of interest. Experiment 4 provides an example of the novel stimuli option. It might also have been possible to train four or more classes, and then to place the tested stimuli into classes without members that have the function of interest. In that manner, control stimuli would be familiar and would be members of equivalence relations, but without other derived response functions on the basis of equivalence.

Use of Developmentally Delayed Populations

Developmentally delayed populations might be used to attempt to reduce the effect of history. If, for example, Experiment 4 were repeated with this population and control subjects responded randomly while experimental subjects responded systematically, then (a) the transfer of general and specific consequential functions would have been shown and (b) extraexperimental histories will have been implicated further as a source of general consequential effects. In such a scenario, the role of history would have to be distinguished from whatever factors were responsible for the developmental delay itself.

Use of Very Young Normal Populations

The use of very young normal children may provide another experimental avenue, unencumbered by issues presented by developmentally delayed populations. This will be difficult. Normal children as young as 24 months of age already show equivalence readily (Devany et al., 1986), and pilot work in our laboratory has identified derived symmetry and exclusion in a normal 16-month-old child. Extremely young children are extraordinarily difficult to work with. They will perform a task for only brief periods of time and thus require many sessions for even the most rudimentary forms of training. Transfer-of-function studies are among the most difficult studies to conduct in the equivalence area, often taking several hours in some cases for a normal adult to complete. With an infant, these same studies could take many months (if they could be completed at all) and, by the time the data were collected, the children could easily already have fairly extensive verbal histories. If, however, such studies could be conducted, they could be very worthwhile. They warrant our best experimental efforts.

Listening for the Bark of the Silent Dog

Another avenue of approach with adult populations is the "talk-aloud" method, in which subjects are asked to describe their thoughts continually as they engage in a task. This has just begun to be used fruitfully in the equivalence area (Wulfert, Dougher, & Greenway, in press). It has been argued (Hayes, 1986) that in certain complex situations, the talk-aloud method can yield information about self-verbalizations with some assurance of reliability. In this so-called "silent dog" procedure, task performance must be assessed in a no-talk condition, a talk-aloud condition, and with different variations of disrupted talk aloud (e.g., asking subjects to summarize their thoughts within intervals). If task performance is the same in the first two conditions but different in the last condition and its variants, it is argued that the lack of effect for talking aloud comes because subjects are already doing something quite similar in the no-talk condition (Hayes, 1986). In other words, the talk is veridical. As it applies to the present question, the source of general consequential and specific consequential functions might be detectable with analysis of talk-aloud protocols (Ericsson & Simon, 1984), especially if the silent-dog procedure is employed successfully.

Direct Manipulation of Contextual and Historical Effects

As noted above, neither equivalence nor the transfer of functions through equivalence seems to be an automatic process. Equivalence class formation itself also seems logically to be under contextual control (Hayes, 1991; Hayes & Hayes, 1989). According to this line of reasoning, the functional reversibility of conditional and discriminative stimuli would be highly destructive in many contexts and, thus, subjects who failed to form equivalence classes only in certain contexts would quickly be weeded out. Only in the realm of social conventions can the development of bidirectional stimulus relations be made to pay off handsomely. These contextual cues or settings might include particular kinds of equivalence tests (Devany et al., 1986; Sidman & Tailby, 1982), an experimental history of equivalence class formation (Kennedy & Laitinen, 1988), a direct history with relational contextual cues (Steele & Hayes, in press), instructions, and similar setting factors.

Contextual control over stimulus-function transfer via equivalence relations has also been demonstrated (Wulfert & Hayes, 1988). This kind of contextual control may be important to understanding the effects of certain verbal stimuli. Consider the question, "What does a lemon taste like?" The word "taste" may be thought of as a context in which the gustatory functions of lemons are activated by the word "lemon," which participates in an equivalence relation with lemons. The word "feel" in the question, "What does a lemon feel like?," might occasion the transfer of tactile functions.

As this applies to the kinds of work needed in transfer-of-function studies, it may be possible to bring the process of acquiring equivalence (not the composition of classes, but relating itself) and both general and specific stimulus functions under contextual control by deliberately manipulating contextual and historical conditions. By manipulating these processes, rather than simply allowing them to occur naturally, more specific information may be obtained about the processes through which contextual cues and history exert control over equivalence and the transfer of functions through equivalence.

Attention to the Kinds of Derived Relations Involved

Many of the published studies on transfer of functions through equivalence classes have examined transfers only between samples and reinforced comparisons (Catania et al., 1989; Gatch & Osborne, 1989; Lazar, 1977; Lazar & Kotlarchyk, 1986). This arrangement permits an appeal to processes such as pairing or stimulus compounding to explain transfer, because the stimulus with the trained function is related directly to the stimulus tested for transfer. At most, it requires an appeal only to symmetry, not to a derived equivalence relation in the definitional sense identified by Fields, Verhave, and Fath (1984). In the present study, the relation between those stimuli given consequential functions directly (the B stimuli) and those stimuli tested for transfer (the C stimuli) was entirely indirect. In Experiment 2, the B and C stimuli were never even seen together. Thus, the observed transfer effects cannot be explained readily on the basis of direct training. Transfer studies will need to attend more precisely to the kinds of derived relations involved in such performances.

Development of More Adequate Theoretical Accounts

The very complexity of questions about semantic relations demands more attention to theoretical development that can narrow the range of variables that need to be considered. Stimulus equivalence does not explain the present results. Equivalence is an outcome concept. Until the process that establishes equivalence and related phemonena is understood, all we can say is that when equivalence forms, these kinds of transfer are likely. The means by which equivalence classes form and such transfer occurs is at present unknown. Some researchers feel that such an account is unlikely, arguing that equivalence is a basic stimulus function produced by biological evolution (Sidman, 1990) and focusing instead on the procedural conditions under which this biologically determined process can operate (Sidman, 1986). We have attempted to account for equivalence on the basis of a history of arbitrarily applicable relational responding (Hayes, 1991; Hayes & Hayes, 1989; Steele & Hayes, in press), but the evidence on either view is slim. In addition, transfer of stimulus functions alone does not provide evidence for stimulus equivalence (Hayes, 1989a; cf. Vaughan, 1988) because a variety of other psychological processes (e.g., stimulus generalization, classical conditioning) can produce the transfer of stimulus functions.

An example of the kinds of theoretical issues requiring greater attention is the distinction between functional and equivalence classes (Hayes, 1989a; Saunders, 1989; Sidman, Wynne, Maguire, & Barnes, 1989; Vaughan, 1988, 1989). It is not yet clear if entirely new functions given to members of preexisting functional classes will transfer through these classes in the absence of equivalence relations (cf. Sidman et al., 1989). Work with both humans and nonhumans is needed, especially if humans use the functional class preparation to derive equivalence relations. Preparations are not processes. For example, we know that a conditional discrimination preparation can give rise to equivalence relations in humans that are not yet seen in nonhumans, even when the same conditional discriminations are acquired. Thus, conditional discriminations alone cannot provide a process account of equivalence, because the same procedure leads to different results—each requiring an account. Similarly, a functional class preparation can lead to equivalence in humans but does not always do so (Sidman et al., 1989), and on that basis alone it seems unlikely that equivalence is due to functional class formation as a process (Sidman, 1990).

The present results may have implications for the analysis of symbolic control and generalization in verbal organisms (Spradlin & Saunders, 1984). The growing literature on rule-governed behavior (Hayes, 1989b) suggests that behavior under verbal control may differ from other behavior, particularly in terms of the psychological processes involved. It has already been shown that extraordinarily elaborate networks of stimulus relations can be established in equivalence training (e.g., Sidman et al., 1985; Steele & Hayes, in press). The derived stimulus relations may themselves be brought under conditional control (Bush, Sidman, & de Rose, 1989; Kennedy & Laitinen, 1988; Wulfert & Hayes, 1988). If experiences with a given stimulus event can affect the psychological functions of stimuli related to that event, and do so under conditional control, then instances of generalization may occur that have a degree of indirectness, scope, and precision that could not readily occur otherwise. These effects may allow us to acquire behavior that could never be learned directly. Such effects have long been noted (e.g., the literature on semantic generalization), but there has not been a basic psychological process to account for them. Equivalence may constitute the beginning of such an account. Thus, control by verbal stimuli may differ from other kinds of stimulus control in the bidirectional flow of the effects of experience and in the extreme degree of precision, scope, and indirectness permitted by conditionally controlled networks of verbal stimuli.

These effects may not always be beneficial or desirable. As has been argued elsewhere (Hayes & Hayes, 1989; Hayes, Kohlenberg, & Melancon, 1989; Hayes, Zettle, & Rosenfarb, 1989), transfer of functions through relational networks may, under some conditions, establish an unhealthy degree of insensitivity to direct contingencies (cf. Hayes, Brownstein, Haas, & Greenway, 1986; Shimoff, Matthews, & Catania, 1986), excessive control by social contingencies (e.g., Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986), improper comparisons of a person's directly experienced environment to a verbally established ideal (cf. Ellis, 1977; Freud, 1956; Rogers, 1961), and similar unhappy effects. In the interests of advancing human functioning, it seems important to learn both how to establish and how to moderate control by verbal stimuli. The transfer of psychological functions through equivalence relations may provide the beginnings of a working model of verbal control amenable to such behavior-analytic research.

REFERENCES

Bush, K. M., Sidman, M., & de Rose, T. (1989). Contextual control of emergent equivalence relations. *Journal of the Experimental Analysis of Behavior,* **51,** 29-45.

Catania, A. C., Horne, P., & Lowe, C. F. (1989). Transfer of function across members of an equivalence class. *Analysis of Verbal Behavior,* **7,** 99-110.

de Rose, J. C., McIlvane, W. J., Dube, W. V., Galpin, V. C., & Stoddard, L. T. (1988). Emergent simple discrimination established by indirect relation to differential consequences. *Journal of the Experimental Analysis of Behavior,* **50,** 1-20.

Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior,* **46,** 243-257.

Ellis, A. (1977). The basic clinical theory of rational-emotive therapy. In A. Ellis & R. Grieger (Eds.), *Handbook of rational-emotive therapy* (pp. 3-34). New York: Springer.

Ericsson, K. A., & Simon, H. A. (1984). *Protocol analysis: Verbal reports as data.* Cambridge, MA: MIT Press.

Fields, L., Verhave, T., & Fath, S. (1984). Stimulus equivalence and transitive associations: A methodological analysis. *Journal of the Experimental Analysis of Behavior,* **42,** 143-157.

Freud, S. (1956). Mourning and melancholia. In J. Riviere (Trans.), *Collected papers* (Vol. 4, pp. 152-170). London: Hogarth Press.

Gatch, M. B., & Osborne, J. G. (1989). Transfer of contextual stimulus function via equivalence class development. *Journal of the Experimental Analysis of Behavior,* **51,** 369-378.

Hayes, S. C. (1986). The case of the silent dog—verbal reports and the analysis of rules: A review of Ericsson and Simon's *Protocol analysis: Verbal reports as data. Journal of the Experimental Analysis of Behavior,* **45,** 351-363.

Hayes, S. C. (1989a). Nonhumans have not yet shown stimulus equivalence. *Journal of the Experimental Analysis of Behavior,* **51,** 385-392.

Hayes, S. C. (Ed.). (1989b). *Rule-governed behavior: Cognition, contingencies, and instructional control.* New York: Plenum Press.

Hayes, S.C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 19-40). Reno, NV: Context Press.

Hayes, S. C., Brownstein, A. J., Haas, J. R., & Greenway, D. E. (1986). Instructions, multiple schedules, and extinction: Distinguishing rule-governed from schedule-controlled behavior. *Journal of the Experimental Analysis of Behavior,* **46,** 137-147.

Hayes, S. C., Brownstein, A. J., Zettle, R. D., Rosenfarb, I., & Korn, Z. (1986). Rule-governed behavior and sensitivity to changing consequences of responding. *Journal of the Experimental Analysis of Behavior,* **45,** 237-256.

Hayes, S. C., Devany, J. M., Kohlenberg, B. S., Brownstein, A. J., & Shelby, J. (1987). Stimulus equivalence and the symbolic control of behavior. *Revista Mexicana de Análisis de la Conducta,* **13,** 361-374.

Hayes, S. C., & Hayes, L. J. (1989). The verbal action of the listener as a basis for rule governance. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 153-190). New York: Plenum Press.

Hayes, S. C., Kohlenberg, B. S., & Melancon, S. M. (1989). Avoiding and altering rule-control as a strategy of clinical treatment. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 359-385). New York: Plenum Press.

Hayes, S. C., Zettle, R. D., & Rosenfarb, I. (1989). Rule following. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 191-220). New York: Plenum Press.

Kennedy, C. H., & Laitinen, R. (1988). Second-order conditional control of symmetric and transitive stimulus relations: The influence of order effects. *Psychological Record,* **38,** 437-446.

Kohlenberg, B. S., Hayes, S. C., & Hayes, L. J. (in press). The transfer of contextual control over equivalence classes through equivalence classes: A possible model of social stereotyping. *Journal of the Experimental Analysis of Behavior.*

Lazar, R. (1977). Extending sequence-class membership with matching to sample. *Journal of the Experimental Analysis of Behavior,* **27,** 381-392.

Lazar, R. M., & Kotlarchyk, B. J. (1986). Second-order control of sequence-class equivalences in children. *Behavioural Processes,* **13,** 205-215.

Rogers, C. R. (1961). *On becoming a person.* Boston: Houghton Mifflin.

Saunders, K. J. (1989). Naming in conditional discrimination and stimulus equivalence. *Journal of the Experimental Analysis of Behavior,* **51,** 379-384.

Shimoff, E., Matthews, B. A., & Catania, A. C. (1986). Human operant performance: Sensitivity and pseudosensitivity to contingencies. *Journal of the Experimental Analysis of Behavior,* **46,** 149-157.

Sidman, M. (1986). Functional analysis of emergent verbal classes. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and integration of behavioral units* (pp. 213-245). Hillsdale, NJ: Erlbaum.

Sidman, M. (1987). Two choices are not enough. *Behavior Analysis,* **22,** 11-18.

Sidman, M. (1990). Equivalence relations: Where do they come from? In D. E. Blackman & H. Lejeune (Eds.), *Behaviour analysis in theory and practice: Contributions and controversies* (pp. 93-114). Hove, England: Erlbaum.

Sidman, M., Kirk, B., & Willson-Morris, M. (1985). Six-member stimulus classes generated by conditional-discrimination procedures. *Journal of the Experimental Analysis of Behavior,* **43,** 21-42.

Sidman, M., & Tailby, W. (1982). Conditional discriminations vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior,* **37,** 5–22.

Sidman, M., Wynne, C. K., Maguire, R. W., & Barnes, T. (1989). Functional classes and equivalence relations. *Journal of the Experimental Analysis of Behavior,* **52,** 261–274.

Spradlin, J. E., & Saunders, R. R. (1984). Behaving appropriately in new situations: A stimulus class analysis. *American Journal of Mental Deficiency,* **88,** 574–579.

Steele, D. L., & Hayes, S. C. (in press). Stimulus equivalence and arbitrarily applicable relational responding. *Journal of the Experimental Analysis of Behavior.*

Vaughan, W., Jr. (1988). Formation of equivalence sets in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes,* **14,** 36–42.

Vaughan, W., Jr. (1989). Reply to Hayes. *Journal of the Experimental Analysis of Behavior,* **51,** 397.

Wulfert, E., Dougher, M. J., & Greenway, D. E. (in press). Protocol analysis of the correspondence of verbal behavior and equivalence class formation. *Journal of the Experimental Analysis of Behavior.*

Wulfert, E., & Hayes, S. C. (1988). Transfer of a conditional ordering response through conditional equivalence classes. *Journal of the Experimental Analysis of Behavior,* **50,** 125–144.

Received January 24, 1990
Final acceptance February 24, 1991